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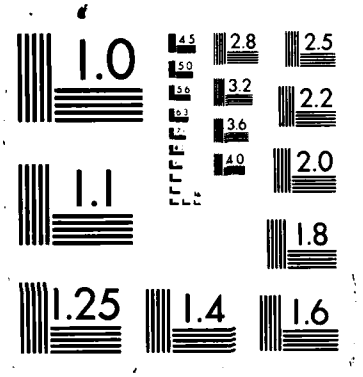
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# TOWARD AN ARTIFICIAL INTELLIGENCE ENVIRONMENT FOR DTIC: STAFFING QUALIFICATION CRITERIA FOR AI APPLICATION DEVELOPMENT

Allan D. Kuhn
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February 1987



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This report discusses in a general manner the recognized development areas of Artificial Intelligence (AI) in the AI community. These areas are concisely described in relation to DTIC STIP AI activity. Technical problem areas and current AI effort areas are also briefly discussed. Taking these three basic areas into account, the recommended staffing qualification criteria are established, with the goal of having a DTIC AI staff that will function at a very high level of quality in view of the DoD information community that DTIC serves. Candidate AI development tasks are included.

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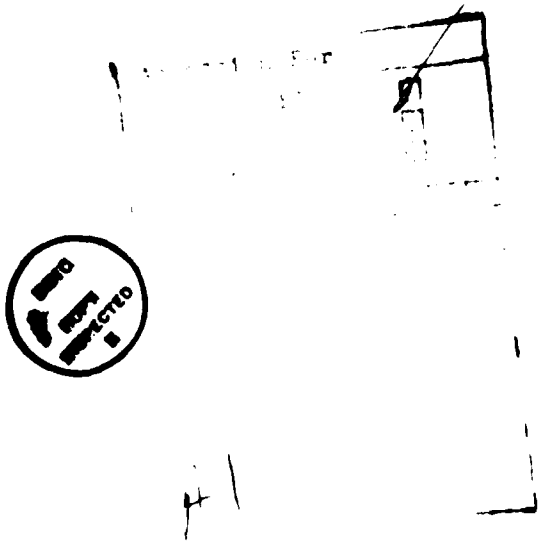

TOWARD AN ARTIFICIAL INTELLIGENCE ENVIRONMENT FOR DTIC:
STAFFING QUALIFICATION CRITERIA FOR AI APPLICATION DEVELOPMENT

## EXECUTIVE SUMMARY

The following paper discusses in a general manner the recognized development areas of artificial intelligence (AI) in the AI community. These areas are concisely described in relation to DTIC STIP AI activity. In addition to AI development areas, technical problem areas and current AI effort areas are briefly discussed. Taking these three basic areas into account, the recommended staffing qualification criteria are established, with the goal of having a DTIC AI staff that will function at a very high level of quality in view of the DoD information community that DTIC serves.

The qualification criteria are:

1. Master's Level:

   . AI programming knowledge: Must be very familiar with C/UNIX programming. Extensive AI programming in one of the three programming languages: LISP, Smalltalk, PROLOG; and familiarity with the concepts of the other two.

   . Knowledge representation techniques: Frame, Rule, ATN, Semantic Networks, etc.

   . Planning and Search: Problem-solving tactics and planning, heuristics search, search methods such as Alpha-Beta search and And/Or graph search, goal trees.

   . Logic reasoning/deduction: First-order logic, theorem proving, logic programming.

2. Ph.D. Level:

A Ph.D. will have all the above, and will have an advanced research specialty area. The selection of a Ph.D. candidate will be based on how the specialty serves the DTIC STIP mission.

3. Non-computer-science background: A person's undergraduate orientation or earlier professional area is to be considered, also. Computer Science is not strictly necessary. Education and profession in humanistic areas are to be taken into account as areas relative to human intelligence, condition, and communication.

This report also includes a listing of AI candidate tasks (Appendix A) to launch AI activities, and encapsulizes AI expert system uses and terminology (Appendix B) as some aspects of AI development applications.

The purpose of this paper is to support the concept that DTIC's AI activity mission will be to search out DoD information problem areas, evaluate them for potential AI applications, contruct applications using currently available software while at the same time making use of cutting-edge AI technology, and implement those applications in a timely manner. This will be done through a staff of highly qualified and highly motivated AI activity Fellows.

Additionally, the AI activity will establish liaison with AI researchers and experts in the government, industry, and academia. In doing so, the lab will not only be able to draw on the AI community's resources, but in return contribute to the AI community.

CONTENT

# TOWARD AN ARTIFICIAL INTELLIGENCE ENVIRONMENT FOR DTIC: STAFFING QUALIFICATION CRITERIA FOR AI APPLICATION DEVELOPMENT

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## I. INTRODUCTION

What is AI? According to Roger Schank of Yale University (see References), there are two responses. In the current state of artificial intelligence the scientific response is that AI is a modern methodological tool that is used in the ancient enterprise of the study of the mind. The technological response is that AI development is an attempt to create new technology.

These two answers illustrate the general perception of AI; it is at the same time explanatory and illusive. AI should be approached as such. AI does not give hard and fast, black and white answers, just as the human mind does not. What AI does give, however, is a universally recognized potential for the future that is exploratory and unconstrained.

AI falls in line with the concept that the best way to predict the future is to create it. Artificial intelligence as a study of human mind replication is a futuristic activity. But in fact the threshold of such futuristic development has already been crossed. A DTIC AI environment would pick up on current AI developments in studying and creating AI applications in the DoD information community. See Appendix B for a brief outline of AI uses, using expert systems as an example.

A DTIC goal is to increase information services directly to DoD endusers. DoD endusers are the managers, engineers, and scientists. These users depend on accurate and up-to-date information to fulfill their mission assignments. Proliferation of terminal and microcomputers makes database access feasible for the DoD enduser. But a major obstacle for enduser database utilization, for example, is knowing what and how to search. These users need a system that will allow them to identify, access, and query databases using natural language dialogs. Artificial Intelligence technology applied to information retrieval systems offers a means to satisfy these user needs.

A DTIC development already active and at the threshold of AI activities is the DoD Gateway Information System (DGIS). The DGIS has been developed to give rapid, easy access to scientific and technical information. It has been designed to provide the DoD enduser with a single, user-friendly system front-end that can be used to identify, access, interrogate, and postprocess information from numerous databases. The development of these functions, however, indicate that there are areas where there is a potential for more graceful functioning through AI applications.

An AI technology environment needs proper staffing. The purpose of this paper is to establish a set of staffing qualification criteria that will provide the Defense Technical Information Center (DTIC) a high quality research environment in its Artificial Intelligence applications. The paper takes into consideration the areas of AI application studies and specialties, technical problem areas, and current efforts and achievements. If DTIC makes use of all

these aspects to maximize a quality environment, the results will be high quality, application-specific, gracefully functioning products. Such an environment will provide high-level and professionally dedicated interaction among the AI participants. With this level of communication and spirit, the developments of DTIC can be seen as the result of fully synergistic efforts toward understanding and accomplishing the future-driven tasks given to DTIC Artificial Intelligence activities.

For a listing of candidate tasks to launch DTIC AI developments, see Appendix A.

## II. THE APPLICATION DEVELOPMENT AREAS IN AI

The following lists AI application study and specialty areas. A well-constituted amalgamation of the research and application concepts involved in these areas are necessary for an operational activity. No single person can be knowledgeable about all these areas. But a group of AI "Fellows" can be brought together who as a group can embody the essential knowledge for DTIC AI research, development, and implementation. The areas are assigned levels of necessity relative to the scientific and technical information program (STIP) missions of DTIC.

1. Computational Linguistics.
    a. Natural language interfaces (natural language orientation is inherent).
    b. Machine translation.
    c. Text generation.
    d. Concept extraction.
    e. Linguistics:
        . Syntactical-based systems (case grammar, transformational grammar, etc.).
        . Semantic-based systems.

    Essential requirement.

2. Knowledge Representation.
    a. Logic-based representations.
    b. Semantic Networks and Frame representations.
    c. Rule-based representations.
    d. Procedural-analog representations.
    e. Object-oriented representations.

    Essential requirement.

3. Expert System Technology.
    a. Knowledge engineering.
    b. Expert system protocols development.
    c. Expert engineering problem solving.
    d. Expert system shell.

    Essential requirement.

4. AI Architecture.
    a. AI computer systems/hardware.

    Essential requirement.

5. AI Applications.
    a. Education and Computer-Assisted Instruction (CAI)
    b. Programming environment assistance (e.g., Programmer Apprentice).

    Secondary requirement.

6. Learning and Acquisition.
    a. Induction.
    b. Failure-driven learning.

c. Learning by analogy.
d. Learning by exploration.
e. Learning language.

Essential requirement.

7. Theorem Proving/Logic Programming.
   a. Mathematical theorem proving.
   b. Deductive retrieval.
   c. High order logic systems, non-standard (modal, temporal) logic system.

Essential requirement.

8. Common Sense Reasoning.
   a. Default reasoning.
   b. Truth maintenance system.
   c. Non-monotonic reasoning.

Essential requirement.

9. Distributed Problem Solving (vis-a-vis ES single system).
   a. Problem solving in a distributed environment.
   b. Multiple expert systems.

Essential requirement.

10. Cognitive Modelling.
   a. Modelling creativity, discovery.
   b. Modelling human problem solving.
   c. Modelling learning and adaptivity.
   d. Modelling programming activity.
   e. Modelling database searcher.

Secondary requirement.

11. Vision.
   a. Visual processing based on human vision effect.

No requirement other than awareness of concepts.

12. Robotics.
   a. Intelligent robots and machine systems.

No requirement other than awareness of concepts.
Robotics development involves a lengthy list of component systems that requires extensive integration to achieve the intelligent robot.

## III. DTIC AI ACTIVITY PARTICIPATION QUALIFICATION CRITERIA

A high quality Fellow, then, can be considered as one who has the background and experience that encompass the above AI areas. The qualification criteria for an AI Fellow are:

1. Master's Level:

   . AI programming knowledge: Must be very familiar with C/UNIX programming. Extensive AI programming experience in one of the three programming languages: LISP, Smalltalk, PROLOG; and familiarity with the concepts of the other two.

   . Knowledge Representation Techniques: Frame
     Rule
     Augmented Transition Network (ATN)

Semantic Network
etc.

. Planning and Search: Problem solving tactics and planning.
Heuristics search.
Search methods, e.g., Alpha-Beta search
And/Or graph
Goal trees.

. Logic Reasoning/Deduction: First Order Logic
Theorem proving
Logic programming

2. Ph.D. Level:

A Ph.D. will have the background of the above, but will have an advanced research specialty involving this background. The selection of a Ph.D. applicant will have to be based on how one's specialty will serve DTIC STIP missions.

3. Ancillary qualification - non-computer-science background:

A person's undergraduate orientation or earlier professional area is also to be considered. Computer Science is not strictly necessary. Education and profession in humanistic areas are also to be taken into account, as areas of experience relative to human intelligence, condition, and communication.

## IV. AI APPLICATIONS EXPERTISE

In applications research for successful implementation, it is imperative that an AI Fellow have an awareness of general AI technical problems. This awareness is used to anticipate problem areas, and pre-empt those problems prior to implementation. High-quality efforts would consider such a practice to be standard to the DTIC AI environment for creating high quality products.

The following technical problem areas, as listed by Schank, are recognized generally:

1. Domain Prediction and Error Explanation.

   Involves prediction theory, error recovery, error explanation, and new theory creation.

2. Representation Theory.

   Involves change and alteration of representation structures over time.

3. Search.

   Representations that obviate the need for reliance on algorithmic search.

4. Reconstructive Memory.

   The phenomenon of providing answers from incomplete data.

5. Generalization.

   Being able to program for a testable generalization from supposedly unconnected experiences, drawing conclusions from the disparate data of those experiences.

6. Reasoning from Cases.

   The embodiment of human expertise in cases rather than in rules; the essence of expertise is derived from particular and singular cases that

stand out in the expert's mind.

A further indication of a sound expertise is an awareness of current AI efforts and achievements. This awareness will establish a direction that is an avenue into the future. These elements, most listed by Nilsson (see references), are:

1. Propositional Doctrine.

   Structuring a declarative knowledge base, with emphasis on propositional and declarative representations, plus an inference mechanism.

2. Reflection Principles and Semantic Attachment.

   The theory dealing with how propositional and procedural knowledge are connected to partial models.

3. Real Problems.

   The handling of major bodies of expert knowledge concerning real problems in representing them through propositional formalisms.

4. AI Program Controls:

   . Procedural knowledge - Embedding procedural knowledge to control deduction effectively.

   . Heuristic search processes - Control by employing knowledge from the problem domain.

   . Meta-level control processes - The idea that knowledge needed for control can be best represented propositionally rather than procedurally in order to decide what the object level reasoning system ought to do next.

5. Controlled Deduction.

   The idea that a controlled search for a chain of deductions can play the role of computation.

6. Speech-Act Theory.

   The view that the generation of sentences in natural language by cognitive agents is a deliberate process planned to achieve specific changes in the cognitive state of the hearer or reader of such sentences; impacts natural language generation and interpretation.

7. Commonsense Reasoning.

   . Commonsense knowledge and naive physics - Formalizing commonsense domains based on the physics of everyday experience.

   . Knowledge and reasoning representation - Representing and reasoning about knowledge, belief, and other propositional attitudes or cognitive states such as desires and intentions; impacts AI systems' ability to reason.

   . Nonmonotonic reasoning. - Withdrawing a previously deduced conclusion in response to learning a new fact; falls in line with human reasoning as compared with rules creating non-changing conditions.

8. Neural Networks.

   Replication of human brain neuron activity. The synthesization of thought closer to human thought processes than has been previously achieved.

Includes associative memory and recall, self-learning activity, distributed memory, distributed activity patterns.

As is seen from the above, the AI development universe is vast. It will be imperative to establish liaison with AI experts and researchers throughout the government, industry, and academia. Through this liaison the DTIC will not only be able to draw on the AI community's resources, but also in return contribute to the AI community.

## V. THE PROPOSED MISSION FOR DTIC ARTIFICIAL INTELLIGENCE APPLICATION

DTIC's AI mission will be to search out DoD information problem areas, evaluate them for potential AI application, construct applications using currently available ware while at the same time making use of cutting-edge AI technology, and implement those applications in a timely manner.

This will only be possible, however, through a staff of highly qualified and highly motivated AI activity Fellows.

## REFERENCES

Section IV. AI APPLICATIONS EXPERTISE has drawn heavily and liberally on the two articles below; Nilsson is Director of the Artificial Intelligence Center, Stanford Research Institute, and Schank is Professor of Computer Science and Psychology at Yale University:

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AI Magazine. Quarterly.
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IEEE Expert. Quarterly.

Journal of Computational Linguistics.
Publication of the Association of Computational Linguistics.

## APPENDIX A

## CANDIDATE AI DEVELOPMENT TASKS

To initiate the AI activities as rapidly as possible, the following tasks are presented as candidate AI development activities. The goal of this AI development is to multitask the machine through AI technology, and in doing so, make the machine more human-like.

Common Command Language Search Assistant -

This development is currently taking place as part of the DoD Gateway Information System (DGIS) Common Command Language activity. CCL now involves incorporating PROLOG with the previous C Language development.

Routine Generator Expert System -

An Expert System for developing routine generators, such as for the NAM connection agents, postprocessing translators, and Common Command Language translators. These generators would not only serve programmers, but also endusers for providing immediate access to routines applied to databases new to the system.

Information Processor Systems -

AI-based systems that would enhance and expand the quality of information processing; would include a duplicate and irrelevant data analysis system, a relevant analysis system, analysis graphics, and a tailored product system incorporating cover, content, tables, graphics, and indices.

Thesauri Integration for Expert Searching -

Development of a system to apply external database thesauri for determining relevant databases in response to a user's intended search query.

Diverse Database Query Expert System -

The refinement of a query ("Is this what I am really asking?"), and transmission of the query to the appropriate databases, relative to the functionalities, e.g., subject searching, full text, scanning, trending and projecting.

Numeric Information Query and Processing System -

System for identifying numeric information and its sources, and aggregating, analysing, and synthesizing that information.

Portable Natural Language Interface -

Natural language interface commonly usable with programs, routines, functions, and other areas and aspects of the electronic system.

Natural Language Interface to UNIX -

Natural English language interface to cryptic UNIX, to include the

identification of UNIX functions by the user's natural language description.

Foreign Human Language Interfaces -

To incorporate passive and interactive machine translation, for searching foreign databases, to communicate interactively with foreign language databases with translation between English and the language of the database, and to communicate passively and interactively with foreign language speaking people.

APPENDIX B

EXPERT SYSTEM GENERIC CATEGORIES & TERMINOLOGY

The following lists the generic categories of expert systems application, and terminology used. It is provided as information for showing representative areas of artificial intelligence.

* * * *

Interpretation - Inferring situation descriptions from sensor data.

Prediction - Inferring likely consequences of a given situation.

Diagnosis - Inferring system malfunction from observables.

Design - Configuring objects under constraints.

Planning - Designing actions.

Monitoring - Comparing observations to plan vulnerabilities.

Debugging - Prescribing remedies for malfunctions.

Repair - Executing a plan to administer a prescribed remedy.

Instruction - Diagnosing, debugging, and repairing student behavior.

Control - Interpreting, predicting, repairing, and monitoring system behaviors.

Recognition - Object recognition based on given complete/incomplete description.

Database - Translating ES search request to database queries; help user formulate database queries.

* * * *

AI and expert systems terminology is shown below, with its corresponding computer science terminology. This information is provided by Peter Bar[illegible] Syntelligence.

| AI & Expert Systems | Computer Science |
|---|---|
| Knowledge Engineer | Programmer Analyst |
| Knowledge Base | Program |
| Expert System Shell | Programming Language |
| Knowledge Acquisition Tool | Programming Environment |
| Inference Engine | Interpreter |

The reasons for the differences in terminology are

Third generation languages (Fortran, COBOL, etc.) are algorithmic; functions operate sequentially based on yes-no decision points, with known and pre-defined goals as results.

AI functions conceptually in a concurrent processing manner; there are many parallel decision points, none of them yes-or-no, but rather "this" or "that".

In algorithmic programming, the programming language is the program.

In AI the information is the program.

Algorithmic programming provides information.

AI information programming provides knowledge.

Algorithmic programming gives you an item of information, or it doesn't.

AI gives you information that may or may not be pertinent toward making a decision.

This is the way the mind works.

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